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THE NECESSITY OF COMPETENT SUPERVISION AND CAREFUL LABORATORY CONTROL IN THE OPERATION OF WATER PURIFICATION PLANTS[1]

By Lewis I Birdsall[2]

Eternal vigilance is the price of pure water. Every water purification plant from the smallest liquid chlorine installation to the largest and most complete filtration plant should be operated under competent supervision and careful laboratory control.

The cheapness and demonstrated effectiveness of liquid chlorine as a sterilizing agent for water supplies have induced many water works officials in Minnesota, as elsewhere in the United States, to rely on chlorine as the sole means of water purification. Such an installation may, however, merely afford a false sense of security. Failure to keep up the chlorine treatment continuously and in amount sufficient for sterilization of the water may mean a typhoid fever epidemic in the community. This danger is greatest among the smaller water works plants where one man is frequently responsible for the operation of the pumps and the chlorine machine. The result is that the pumps get most of his attention and the chlorine machine is neglected.

There are many water works plants, and among them some that are not small plants, that rely for chlorine sterilization on one machine only, so that when it is necessary to change chlorine cylinders or to make necessary repairs, the chlorine feed has to be discontinued. Too much stress cannot be placed on the necessity of duplicate installations of liquid chlorine machines wherever used, so that when one machine is taken out of service the other may be put in service immediately and continuous treatment be obtained. There should also be kept on hand a supply of extra parts for the chlorine machines, so that ordinary repairs may be quickly made in case of emergency.

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[1] Read before the Minnesota Section, December 6, 1919. Discussion of this paper is requested and should be sent to the Editor.

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Our state boards of health should require duplicate installations of liquid chlorine machines and it would also appear that the manufacturers of the machines might be led to see the advantage to themselves as well as to the various communities served, in making a substantial reduction in the selling price of two machines to the same purchaser as compared with the price of one machine. The price of repair parts should also be kept as low as possible and all users of the machines be urged to keep a supply of extra parts on hand.

Chlorine cylinders that are in service should be placed on scales and a record be kept of the weight of the cylinders every hour, not only as a check on the manometer gauge of the chlorine machine but also to accustom the operators of the plant to inspect the machines frequently to see that they are working properly. The scales prevent chlorine cylinders from going empty unexpectedly and the recorded weights serve as a check on the faithfulness of the operator provided that the amount of water treated each hour is accurately determined.

But how shall we know that we are adding the proper amount of chlorine to the water in order to obtain sterilization at all times? There is no general rule for the amount of chlorine to use. The suspended matter, dissolved organic matter and the bacterial content of surface waters, especially river waters, are constantly changing. The amount of chlorine necessary for sterilization of the water is influenced by all three of these factors. A filtered water or a fairly clear and pure water requires less chlorine than does a turbid water or one containing a large amount of dissolved organic matter. Whereas a treatment of 0.3 part per million (2½ pounds of chlorine per million gallons) may be satisfactory in the first case, a much larger dose is required in the latter instance. Residual tastes and odors must be considered in the treatment of some unfiltered waters. A slight variation in the amount of chlorine added may mean either under-treatment and lack of sterilization or over-treatment and complaints from the water consumers. Sterilization takes place less readily in cold water than it does in warm water, and so it is necessary to allow a longer period for the reaction in winter than in summer. Experience has shown that free chlorine disappears much more rapidly from the treated water when the water is passed through iron pipes than when it goes through a concrete conduit.

It is evident that in order to regulate the chlorine treatment properly there must be laboratory control. The test for free chlorine in the treated water, and the determinations of the number of bacteria and the presence or absence of B. coli in the untreated and treated waters offer such control tests. Because of the lag of 48 hours in the results of the bacteriological tests made necessary by the incubation of the inoculated media, it is advisable in most plants to add sufficient chlorine to the water to produce a slight residual free chlorine content of approximately 0.05 part per million. Some waters, as stated above, do not permit of over-treatment, but such waters are comparatively few, and where they occur, the treatment requires very careful supervision. In the majority of cases, therefore, the chemical test for free chlorine becomes the one on which we rely for sudden changes in the chlorine treatment, and the test should be made several times each day. The bacteriological tests indicate the results of the treatment and demonstrate the purity of the treated water. They should be made daily on both the untreated and treated waters.

Chlorine is comparatively cheap, much cheaper than human lives, and therefore it is much more desirable to over-treat a water supply with chlorine than to under-treat it, if reliance for purification is placed on chlorine alone. A chlorine taste in the water, even though it may be unpleasant, is less harmful to the water consumers than a tasteless water that contains typhoid bacilli.

Chlorine sterilization is a valuable adjunct to other methods of water purification, but it should not be depended upon as the only line of defense between a seriously polluted water supply and the water consumers, unless it is so used as a temporary expedient and then only under the most careful supervision.

The laboratory tests necessary for the control of a filter plant are more comprehensive and elaborate than those described for a chlorine plant. Turbidity, color, alkalinity and the bacterial content of the untreated water usually determine the amount of chemical necessary for proper coagulation of the water before it goes to the filters. The same tests on samples of the water as it goes to the filters from the coagulation basins determine the efficiency of the pre-treatment. A properly coagulated and filtered water should have no turbidity and a color of 10 parts per million or less. The bacterial content of the filtered and sterilized water should be as near zero as possible and B. coli should be absent in 50 cc. amounts of the water.

An odor in the untreated water may be caused by algae and a microscopical examination of the water will disclose the offending organism. Odors from manufacturing wastes are sometimes more difficult to eliminate from the water than are those from micro-organisms. Tests for odor should be made on both the untreated and the filtered water.

The alkalinity test demonstrates the presence of carbonates and bicarbonates in the untreated water, and whether or not they are sufficient in amount to decompose the coagulant to be added. The filtered water should at all times have residual alkailinity as a safeguard against the presence of undecomposed coagulant.

Free carbonic acid frequently occurs in surface waters. A determination of the amount present should be made where lime is used in conjunction with iron sulphate as coagulant. The amount of free carbonic acid in the filtered water should be determined because of the part it plays in the corrosion of exposed iron surfaces in distribution pipes.

The test for residual chlorine is essential, as already described above.

Total hardness tests are made at intervals for the purpose of record. Complaints regarding the hardness of the water supply are more easily answered if data are at hand to show that the filtered water is no harder than the untreated water and that the hardness of the water is greater at certain times of the year due to natural causes.

Complete sanitary chemical and mineral analyses of the untreated and filtered waters are made each month in the larger filtration plants for the purpose of record. These data are not necessarily essential for the proper operation of the plant but they are of value for reference.

Analyses of the chemicals used for water purification are valuable and there should be frequent tests of the chemical solutions that are added to the water.

The most essential laboratory tests for the proper control of a filtration plant are those for turbitity, color, alkalinity, residual chlorine, number of bacteria per cubic centimeter and B. coli. The data obtained from these tests will enable the operator to handle his plant economically and efficiently. He will at all times have the satisfaction of knowing the quality of the untreated water and the degree of purification obtained by the plant. The health of a community is the final test by which the purity of a water supply is judged, but the operator of a water purification plant who knows each and every day that the water he is supplying is of the highest purity has nothing to fear from health statistics.

A water softening plant requires certain special laboratory tests in addition to total hardness, alkalinity and free carbonic acid determinations. Only under laboratory control can a softening plant be properly operated.

It seems almost inconceivable that anyone should attempt to operate a water purification plant without daily laboratory control tests, but experience has shown that many plants are so operated. An occasional bacteriological analysis of a water supply, whether monthly or weekly, has little significance. It merely shows the condition of the water at the time the sample was taken. The splendid work of the Sanitary Division of the Minnesota State Board of Health is tending to raise the standard of water purification plants in Minnesota and to demonstrate that the saving of human lives rather than dollars is the high ideal we should have constantly before us.

Texas has set an example to other states by organizing a short course for water works superintendents and purification plant operators at the University of Texas. The local sections of the American Water Works Association can do no greater good for their communities than by stimulating interest in the organization of similar courses of instruction in their state universities and then urging the water works men to attend these courses. The farmers long ago realized the value of short courses at the State University and now attend them annually. Why cannot the Universities do for the water works men what they have done for the farmer? The possibilities for education in this new field are unlimited.

Many small water purification plants are unable to pay the salary of a competent analyst. Such plants no doubt have some employee who could learn to perform some of the more simple routine tests, such as those for turbidity, color, alkalinity and free chlorine, provided the necessary chemical solutions are prepared for him. The bacteriological tests are somewhat more difficult, but even these can be performed by such an employee if he shows an aptitude for the work and provided the necessary media can be furnished. A competent water purification expert could no doubt be employed by a number of such plants at a comparatively small expense to train the operator, interpret the laboratory results thus obtained, furnish the necessary chemical solutions and bacteriological media, supervise the general operation of the plant, and visit the plant periodically. Such an arrangement obtains in some sections of the United States and has been found to work very satisfactorily.

A water purification plant that is operated without laboratory control is merely furnishing a false sense of security to the community. The same plant when operated under laboratory control and competent supervision can and should yield a safe and pure water at all times.